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ABSTRACT

The Revolution in Military Affairs (RMA) was developed in 1989 by Andrew Marshall of the Office of Net Assessment in Washington. Based on Marshal Nikolai Ogarkov's doctrine of the Military-Technical Revolution, the RMA is defined as:

> A major change in the nature of warfare brought about by the innovative application of new technologies which, combined with dramatic changes in military doctrine, operations, and organisational concepts, fundamentally alters the character and conduct of military operations.

Though no official definition exists, these requirements of technological innovation, new doctrine and operations concepts, and organizational change were used in the analysis of the 1991 Gulf War, resulting in the conclusion of the existence of a new RMA.

Known as the 'Information Revolution,' this RMA is centered on stealth technology, precision munitions, advanced sensors and increased communications, command, control, computer and intelligence (C^4I). From these advancements, doctrinal development has taken place in both joint and service centered documents. These new doctrines have introduced the operational concepts of dominant maneuver, precision engagement, focused logistics and full-dimensional protection, culminating in the new core competency of full-spectrum dominance. Organizational changes to allow for the achievement of these new concepts consists of an increased focus on inter-service connectivity for joint operations and the mutation of the traditional military hierarchy into smaller, more mobile forces deployable for rapid reactions and tailored to the specific threat.

Despite the evidence pointing to the emergence of the 'Information Revolution' as a new form of warfare, the concept lacks coherence between its proposed nature and the technological characteristics. This disparity revolves around the lack of attention given to space-based capabilities.

The nature of the space environment provides space-based systems with the ability to provide a constant, global network of communications, navigation and intelligence, surveillance and reconnaissance capability, essential in the achievement of the 'Information Revolution.' The vital role played by space systems was shown during the Gulf War, in which the military relied heavily upon satellite intelligence and communications to illuminate the battlefield and coordinate joint actions throughout the theater. Navigation was also essential in the use of precision-guided munitions and synchronization of attack due to the lack of visual navigation aids in the environment. The integration of space-based systems into military operational doctrine and organization is imperative for the full exploitation of the 'Information Revolution.'

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The New High Ground:

An Analysis of Space-Based Systems in the 'Information Revolution'

By

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ABSTRACT

The Revolution in Military Affairs (RMA) was developed in 1989 by Andrew Marshall of the Office of Net Assessment in Washington. Based on Marshal Nikolai Ogarkov's doctrine of the Military-Technical Revolution, the RMA is defined as:

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Though no official definition exists, these requirements of technological innovation, new doctrine and operations concepts, and organizational change were used in the analysis of the 1991 Gulf War, resulting in the conclusion of the existence of a new RMA.

This RMA is centered on stealth technology, precision munitions, advanced sensors and increased communications, command, control, computer and intelligence (C^4I). From these advancements, doctrinal development has taken place in both joint and service centered documents. These new doctrines have introduced the operational concepts of dominant maneuver, precision engagement, focused logistics and full-dimensional protection, culminating in the new core competency of full-spectrum dominance. Organizational changes to allow for the achievement of these new concepts consists of an increased focus on inter-service connectivity for joint operations and the mutation of the traditional military hierarchy into smaller, more mobile forces deployable for rapid reactions and tailored to the specific threat.

Despite the evidence pointing to the emergence of the 'Information Revolution' as a new form of warfare, the concept lacks coherence in its proposed nature and technological characteristics. This disparity revolves around the lack of attention given to space-based capabilities.

The nature of the space environment provides space-based systems with the ability to provide a constant, global network of communications, navigation and intelligence, surveillance and reconnaissance capability, essential in the achievement of the 'Information Revolution.' The vital role played by space systems was shown during the Gulf War, in which the military relied heavily upon satellite intelligence and communications to illuminate the battlefield and coordinate joint actions throughout the theater. Navigation was also essential in the use of precision-guided munitions and synchronization of attack due to the lack of visual navigation aids in the environment. The integration of space-based systems into military operational doctrine and organization is imperative for the full exploitation of the RMA.

Chapter 1: Introduction

The quest for the decisive edge has been the driving force behind military invention and innovation. Defining military thought and strategy for centuries, the concept of the decisive edge became formalized in the 1970's with the Soviet doctrine of the Military-Technical Revolution, pioneered by Marshal Nikolai Ogarkov. This idea expressed his growing concern over the prospect of a Soviet defeat at the hands of the West due to the relative technological gap.[1] This concept mutated in its path westward, culminating in the revolution in military affairs (RMA), developed by the Office of Net Assessment in Washington, to become a focus of Western strategic inquiry.[2] The amorphous quality of the concept has allowed for various interpretations and a lack of agreement on the actual nature of an RMA. Views range from a MTR based reliance on technological development to the rather Clausewitzian belief that only changes in the strategic political environment can have such revolutionary impact.[3] Despite these conceptual incongruences, the RMA hypothesis became the center of strategic analysis after the victory in the Gulf War in 1991. Most RMA proponents believed they were witnessing the latest RMA phenomenon.

The Coalition victory in the Gulf War was quickly heralded as a watershed for Cold War strategy; a precursor conflict defining the new form of warfare. Though Iraq 'admittedly displayed extraordinary ineptitude at every level', analysts concluded that such a 'one-sided decimation' could only be caused by an extreme disparity.[4] The race was on to determine the necessary response to fully exploit the advantage of this current RMA. Termed the 'Information Revolution', this RMA hypothesis is centered around these technologies of precision forces, stealth, and battlespace control provided by advanced sensors, and increased command, control, communication, computer and intelligence (C^4I) capabilities, seen as key to the Coalition victory.[5] In the decade since the Gulf War victory, military forces around the world have

[1] MacGregor & Murray (2001), p. 3
[2] Gongora (2000), p. 1
[3] Sloan (2002), p. 1
[4] MacGregor & Murray (2001), p. 190
[5] Ibid., p. 4

introduced innovative doctrines, changed procurement strategies, and re-organized military structure based upon this 'Information Revolution'.

However, in the fervor to achieve the most advanced forces, organized to fully exploit the new information abilities, a crucial element of this revolution has been overlooked. As well as being a stunning victory, the Gulf War has also been called the first 'space war', in which space-based systems were highly relied upon in military operations and provided a fundamental capability enabling the victory.[6] During the 1991 conflict, both civilian and military space systems were used to aid in communications, command and control (C^3), intelligence, surveillance and reconnaissance (ISR), navigation and precision engagement.[7] The characteristics of the space environment—the position relative to the Earth, the constancy of operation, and their all weather and nighttime capabilities—renders space-based systems ideal for use in the current RMA. To fully exploit the promise of change and innovation of the 'Information Revolution', emphasis must be placed on the further development and integration of space-based systems. By studying the hypothesis of the RMA and the current environment, it will be possible to determine the nature of the 'Information Revolution'. Once elucidated, this nature will highlight the vital role performed by space-based systems.

The Revolution in Military Affairs:

An inherent difficulty in discussing the current 'Information Revolution' is the amorphous quality of the RMA hypothesis derived from the lack of an official, or at least agreed upon, definition. The concept itself is a hybrid of modern historical thought and the Soviet military theory of the 1970s. The first appearance of this idea is found in the Marxist-Leninist doctrine of the 1920s and 1930s, which highlighted the concept of a major change brought about during World War I.[8] A more dedicated analysis of innovation and military change was performed in 1955 by historian Michael Roberts, who looked at the victories of Gustavus Adolfus and deduced that these were caused by his adaptation to the changing approach to military

[6] Gonzales (1999), p. 13
[7] FAS (1992), p. 2

organizations within European warfare.[9] He defined this transformation as a 'revolution' for the military. These two thoughts were melded together into Marshal Nikolai Ogarkov's formalized the concept of the Military Technical Revolution (MTR) in the mid-1970s. He concluded that the emergence of precision-guided munitions and the increasing lethality of American technology would soon change they way the U.S. would conduct operations and give them the winning edge over Soviet forces.[10] However, it wasn't until 1989, when Andrew Marshall, director of the Office of Net Assessment within the U.S. Department of Defense (DOD), that the current concept of the Revolution in Military Affairs appeared. His formalized definition of the RMA, used within the U.S. DOD, is:

> A major change in the nature of warfare brought about by the innovative application of new technologies which, combined with dramatic changes in military doctrine, operations, and organisational concepts, fundamentally alters the character and conduct of military operations.[11]

This definition placed the necessity of four elements of change for an RMA: a technological catalyst sparking operational innovation, organizational adaptation and evolving military systems and doctrine.

For many in the post-Gulf War DOD, this definition was lacking in its concentration on the technology rather than the root of warfare that exists in politics. An RMA, therefore, can consist of an internal perspective, with the purpose of re-organizing the military of a state, or an external perspective, a means of attaining strategic objectives in the international sphere.[12] From these perspectives, three separate models for the change evolved. The first, and most superficial, is like the MTR, concerning only a fundamental technical innovation and how that technology is applied. The second model in the RMA is that defined by Andrew Marshall, with the accompanying change in operations and organization to make the technological advancement more efficient for the military. From this concept, Andrew Krepinevich, professor of strategic studies at Johns Hopkins University, has identified ten RMAs from the past:

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[8] Ibid., p. 2
[9] MacGregor & Murray (2001), p. 2
[10] Ibid., p. 3
[11] Gongora (2000), p. 1

the development of the infantry with long-bowmen, the Artillery Revolution in the 1400s, the development of navies with mounted artillery in the late 15th century, the Fortress Revolution with the fortified defenses and the *trace italienne*, the Gunpowder Revolution in the 1550s with the innovations of Gustavus Adolfus, the Napoleonic Revolution with the *levee en masse*, the Land Warfare Revolution of the 1800s with mass transportation and railroads, the Naval Revolution in the late nineteenth century, Aviation Revolution at the beginning of the twentieth century and the Nuclear Revolution following the Second World War.[13] The final model is promoted by Cliff Rogers, in which the RMA is a subset of the Military Revolution (MR), where the fundamental change in the economic, political or social nature of the international system necessitates military changes to maintain the strategic edge.[14] Within this model, the RMAs of Krepinevich each occurred within the context of the five Military Revolutions of large-scale military changes accompanying the creation of the nation-state, the creation of mass politics and warfare under Napoleon, the Industrial Revolution, the combination of the Industrial Revolution with Napoleonic warfare in World War I, and the bipolar world resulting after World War II and the invention of nuclear weapons.[15]

From these different models of the nature and extent of changes within the military and strategic environment, the necessary conditions for the presence of an RMA have been developed. To distinguish an RMA from an MTR, the technology must be accompanied by organizational and operational changes. The RAND Corporation described this as the ability to 'render obsolete one or more core competencies...or create one or more new core competencies'.[16] A core competency is a fundamental ability that provides the foundation for a set of military capabilities. By establishing the far-reaching effects of the change in the military, it is possible to decide how much change is required and how strategically important that change will be.

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[12] Cooper (1997), p. 102
[13] Krepinevich, (1994), pp. 32-36
[14] Rogers (2000), p. 22
[15] MacGregor (2001), p. 6
[16] Hundley (1998), p. 9

The concept of the RMA is not without its criticisms, though due to the modern roots of the concept, most are negated by further refinement of the definition. The most fundamental criticism is the reliance of the RMA on technology, rather than politics as a means of change. The Clausewitzian idea of the primacy of politics in warfare is still largely uncontested. War is a political tool and as such any changes outside the strategic political realm can be considered to change only a war fighting capability rather than the 'fundamental nature of warfare'.[17] To deal with this criticism, the emphasis of an RMA is placed in revolutionizing the capabilities of warfare rather than the changing nature of war. However, this criticism provides an amorphous boundary for the RMA concept, allowing for the recognition of actors other than technology being capable of bringing about these revolutions.

The term 'revolution' is another area upon which opponents have taken issue. There is, according to critics, constant change and innovation within the military, and the idea of revolutionary change devalues the constant efforts on improvements.[18] Furthermore, the term 'revolution' indicates an immediate and radical change, which does not exist in any of the proposed RMAs. Proponents of the RMA counter this criticism by redefining the term 'revolution' to symbolize the impact and extent of the changes rather than the time frame in which they take place.[19] Proponents for the RMA recognize the value of constant evolutionary change, arguing that such evolution is necessary for the eventual RMA and do not see its devaluation as inherent. Despite these criticisms, the concept of the RMA has gained acceptance in the defense community, devoting much analysis to the concept and its application to history and the current situation.

[17] Gray (1997), p. 40
[18] Ibid., p. 46

Chapter 2: The 'Information Revolution'

The framework provided by the definitions and models of the RMA I has been readily applied to the post-Gulf War environment, resulting in the conclusion that the military is experiencing the most recent revolution. The difficulty with this hypothesis is, unlike historical examples where post-revolution evidence is available, there lacks the ability to see into the future and determine the outcome. For example, it was possible to comprehend the impact of the French Revolution and *levee en masse* since historians could examine warfare before and after to supposed revolution and illuminate the changes. The current situation defies the ability to look at the warfare after the revolution. The evidence of the RMA must therefore be based upon the current changes in military and the hypothetical changes it will bring to warfare.

The present RMA is defined by those technologies of stealth technology, precision weapons, advanced sensors, and increased command, control, communication, computer and intelligence (C^4I) capabilities, as demonstrated in the Gulf War.[20] These concepts have been combined to form the 'Information Revolution', resulting in the emergence of Information Warfare. The Office of the Chairman of the Joint Chiefs of Staff defines information Warfare, as 'actions taken to achieve information superiority by affecting adversary information, information-based processes, information systems and computer-based networked, while defending one's own...'.[21] This new operational concept gives the military the ability to execute 'complex, orchestrated, high-tempo, simultaneous, parallel operation that overwhelm the enemy's ability to respond' given that information superiority is achieved.[22] By examining the four areas of the current revolution, it is possible to see the direction in which the future forms of war fighting appear to be heading.

The first technology of the RMA is that of stealth technology, augmenting the operational concept of force projection. The concept of low-observable forces is not new; to hide from the enemy until one was ready to attack has always been a highly

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[19] Sloan (2002), p. 144
[20] Cooper (1997), p. 125
[21] Sloan (2002), p. 111

valued tactic, but in the age of radar and cameras this becomes increasingly difficult. The stealth capability of platforms gives the possibility to penetrate high-threat areas and deliver precision attacks, circumventing defense networks. Such systems already in use include the U.S. Air Force's F-117 and B-2 stealth aircraft, the low-acoustic and thermal signatures of the U.S. Army's *Comanche* helicopter and nuclear powered submarines. [23]

Joined with the concept of stealth is precision strike, provided by precision-guided munitions (PGMs) and information superiority. First developed during the Vietnam War, PGMs have increased in accuracy until their effective employment in the 1991 Gulf War, as more advanced guidance and navigation systems became available.[24] Precision munitions offer the possibility of destroying military targets while limiting collateral damage. The current air-based capabilities consists of the Joint Direct Attack Munition (JDAM) missile, capable of destroying targets at over 6 miles in the air, in all conditions.[25] Similarly, a land-based system was developed in the Brilliant Anti-Armor Submunition allowing for targeting of battalion-sized formations in excess of 140 miles away, and the US and Royal Navies are equipped with a GPS-guided Tomahawk cruise missile, reliable over a thousand mile distance.[26]

The final two area of the RMA is more nebulous as it consists not of a single technological advancement, but rather the result of what Admiral Owens calls the system-of-systems: the increase in sensor, collection, storing, transferring, and processing technology working in a network to provide integrated intelligence.[27] It includes advances in ISR and C^4I capabilities. The combination of these abilities has come to be known as Battlespace Awareness, Dominant Maneuver, and Dominant Battlespace Knowledge—the possibility for the reduction of the ever-present Clausewitzian 'fog of war' by having expanded, near real-time knowledge of the position of all enemy and friendly forces, and the ability to share this information

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[22] Ibid., p. 127
[23] Sloan (2002), p. 4
[24] Buchan (2000), p. 141
[25] Sloan (2002), p. 4
[26] Ibid., p. 4
[27] Owens (1996), p. 1

throughout the 'battlespace'.[28] Such information comes from sensors placed on satellites and both manned and unmanned aerial vehicles. During the Gulf War, aerial support was provided by the Joint Surveillance Target Attack Radar System (JSTARS) for land-based targets, Airborne Warning and Control Systems (AWACS) for airspace control, the Pioneer and Predator unmanned aerial vehicle (UAV) for complete surveillance, and space-based support from photographic and radar imaging satellites.[29]

However, the availability of this information through advanced sensor technology is not complete without the capability to share the information and a command and control structure that can act upon the information when it is received. Advanced processing systems and more powerful computers will allow for near real-time analysis of the data from the sensors. By re-organizing into small groups, acting as 'nodes' of a network and linked to a central control, information can be disseminated and actions coordinated for higher tempo operations.[30] This will allow for the domination of the battlefield and the actual reduction of the 'fog of war' by giving the commander the ability to outmaneuver the enemy with such speed and accuracy that they are unable to react, thus 'dominating' the battlespace.

From these areas of 'revolutionary' technology, there have developed three main schools of thought concerning the RMA: system of systems, Dominant Battlespace Knowledge, and Global Reach, Global Power. Admiral William Owens first developed the idea of a system of systems in 1994, bringing forward the concept of 'digital' battlefields, where the processing and networking of information systems becomes more important to success than individual weapons or platforms.[31] The core of this concept rests upon the speed and power of computers, sensors, and relay systems to allow for real-time gathering, processing, and exchange of data. It's weakness as an RMA is derived from the technological base of the concept which requires little force transformation or re-organization within the military, resting

[28] Buchan (2000), p. 141
[29] Sloan (2002), p. 7
[30] Arquilla & Ronfeldt (1997), p. 456
[31] O'Hanlon (2000), p. 12

solely on the capabilities of the systems rather than considering the human element within warfare.

The second school of thought, Dominant Battlespace Knowledge (DBK), accepts the system of systems as a basis for the RMA, but considers the future growth of the sensors available for information gathering to be the true 'silver bullet'.[32] Future warfare will not only be controlled by the speed at which information is processed and dispersed, but also the quality of the information which is gathered, generating the ability to find, track and target all important enemy assets within a battlespace of 200 square nautical miles.[33] The inherent weakness in this concept is again the techno-centric view, but compounded with this is the reliance on technological abilities which do not yet exist. It is difficult to change doctrine and force structure around technology which isn't present.

The final school of thought maintain the premises of the first two, but include a heavy reliance on the ability to deliver ordnance around the world with stealth and light, precise weapons.[34] This school of thought incorporates all the 'revolutionary' technology—precision weapons, stealth technology, increased C^4I capabilities and advanced sensors—equally into one RMA, emphasizing the importance of the air component of the armed forces as the force of the future.[35] The weaknesses of this school of thought come from this single force view which, when viewed concomitant with the technophilia inherent in all three of these schools, renders the thought of an RMA in a similar category as Star Wars.

Though all these schools of thought contain inherent weaknesses, this does not negate the possibility of a current RMA, but rather emphasizes the need to continue actively pursuing change and development rather than settling for technological solutions. An essential redirection came with the dissemination of the Pentagon's Quadrennial Defense Review in 1997, Joint Vision 2010 in 1996, and Joint Vision 2020 in 2000. These documents produced the official U.S. DOD commitment to 'harnessing new

[32] Ibid., p. 13
[33] Ibid., p. 13
[34] Ibid., p. 14
[35] Ibid., p. 15

actions of other actors, and the frailties of machines and information'.[41] While information superiority remained a focus, it expanded to include decision superiority: the ability of commanders to effectively and jointly use the information to make decision on the battlefield, as the useful extension and information operations as an operational art of its own.[42] These joint doctrines have laid the doctrinal foundation needed to instigate concrete change in the military in pursuance of the RMA.

From Joint Vision 2010 and Joint Vision 2020, each service has developed a distinct vision and doctrine for the future, the most complete being provided by the U.S. Army Force XXI. First developed following the Joint Vision 2010, Force XXI is the re-conceptualization and redesign of all echelons of the Army to transplant focus to interconnectivity and the creation and sharing of action-based information.[43] The Army doctrine restructures the military hierarchy into versatile, modular teams for the purpose of decreasing reaction time and allowing for deployed units to be tailored to the threat. Force XXI revolves around rapid reaction combat teams of approximately brigade size, which would be fully deployable to any theatre in less than 4 days.[44] These organizational premises were placed in the Army's Training and Doctrine Command (TRADOC) Pamphlet 525-5, along with the idea of full-dimensional operations, to provide the official guidance for the training and education of all Army personnel in this new way of warfare.[45]

The U.S. Navy and Marine Corps have similarly issued their future doctrine publication, *Forward...from the Sea* and *The Future...from the Sea*, to transition from open-sea warfare, to a more 'jointness' oriented force to allow for operations from the sea to support land-based forces.[46] These doctrines, like that of the Army, have presented, as one of its required core competencies, the existence of an expeditionary force with threat-centered organization to effectively project power throughout the world.[47] Within this doctrine, the Navy and Marine Corps have accepted the

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[41] JV 2020 (2000), p. 9
[42] Sloan (2002), p. 34
[43] Galdi (1995), p. 14
[44] Sloan (2002), p. 36
[45] Galdi (1995), p. 16
[46] Ibid., p. 21
[47] The Future...From the Sea (1998), p. 2

importance of gaining information superiority in the battlespace and have molded the theory of DBK into new operational concepts of battlespace control, battlespace attack and battlespace sustainment.[48]

Air Force 2025 is the Air Force manifestation of Joint Vision 2020 with the emphasis placed upon the role of force projection. The emphasis of this study places the need for growth and maintenance of global ISR capabilities, aerial strike with precision munitions and unmanned vehicles, and the increase of information fusion and dissemination using integrated technologies from air and space.[49] The focus of this doctrine is based in the attainment of new technologies and the increasing of the core competencies of global view, global reach and global power—the ability to gather information and monitor situations, project force and provide airlift, and strike strategic targets anywhere in the world.[50]

While these visions provide a future focus for the U.S. military and fulfill the need for guiding doctrines for change, actual transformation must be taking place in order for the RMA hypothesis to progress. The U.S. Army, as well as having the most detailed future vision, has also provided a plan with the most concrete process. The force transformation is planned in three phases. The first is the modernization of their existing forces, with the addition of digital technology to aircraft, tanks, artillery and soldier-based systems providing commanders with battlespace knowledge while maintaining competent capabilities for current missions.[51] In pursuit of this, the Army has fielded the first 'digitized' division, 4th Infantry Division (Mechanized), with plans to provide a 'digital' corps by 2004.[52] The second phase consists of re-organizing combat brigades into four thousand person combat teams to form interim forces between the traditional heavy forces and the new light, mobile units. The Army has begun acquiring Light Armored Vehicle (LAV III) to outfit five to eight interim brigades in lieu of Crusader howitzer systems and Abrams tanks, designed for heavier units.[53] The final step in the process is the re-organization of the force around

[48] Ibid., p. 5
[49] Air Force 2025 (1995), p. 2
[50] Galdi (1995), p. 20
[51] Sloan (2002), p. 41
[52] Ibid., p. 42
[53] Ibid., p. 42

deployable brigade combat teams with the centerpiece being the Future Combat System, a lighter tank to replace the heavier Abrams.[54] The Army has begun no actual force transformation towards the realization of the interim or final force structure.

The Army has also taken steps to continue innovation and to ensure a smooth transition. The Louisiana Maneuvers Task Force was created in 1992 to successfully implement and control the integration of the ideas of Force XXI into an operational force, to include combat, support, logistics, intelligence and training.[55] It has also promoted the education of personnel in the future structure of the force through the Army War College and the Battle Labs to analyze the new operational concepts.[56]

Similar to the Army, the U.S. Navy suffers from a lack of impetus to begin the actual transformation of the force structure. Provided with a solid doctrine in *The Future...from the Sea*, the U.S. Navy has yet to take any concrete actions. The acquisition of the land attack destroyer, DD-21, is the only actual movement towards a pursuance of the land-based support warfare.[57] The Navy has, however, operated the Fleet Information Warfare Center since 1995, which applies information-based technologies to provide a networked information gathering and sharing capability.[58]

The U.S. Marine Corps, however, has begun a transformation strategy to reflect the doctrine. It has started development on an airlift force, capable of lifting combat teams inland in the vicinity of the target.[59] While already equipped with an expeditionary style force, the acquisition of the V-22 Osprey and the Joint Strike Fighter will increase the effectiveness of this capability.[60] The Marine Corps has also developed the Marine Corps Commandant's War fighting Laboratory to provide a test

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[54] Ibid., p. 43
[55] Galdi(1995), p. 18
[56] Ibid., p. 18
[57] Sloan (2002), p. 40
[58] Galdi (1995), p. 22
[59] Sloan (2002), p. 41
[60] Ibid., p. 42

bed for the conversion of the new doctrine and technological capacity into operational concepts and tactics.[61]

The Air Force, though providing limited guidance in their doctrinal documents, has placed great effort into its transformational efforts. From readiness problems experienced in Operation Allied Force in 1999, the Air Force has divided its entire force, including reserve forces, into ten expeditionary forces, each representing complete aerospace means from precision strike to airlift.[62] While the organizational changes are advanced, the Air Force acquisition has placed little emphasis on exploiting the new technology of UAVs and maintained focus in short-range aircraft, requiring overseas bases for deployment.[63] While this limited transformation brings into question the time frame of actual operability of the new re-structured U.S. forces, the pursuance of change offers confirmation for the RMA hypothesis.

Though a U.S. led concept, the current hypothesis has been accepted by many nations, and steps are being taken to modify these nations' forces to meet the requirements of the RMA. Great Britain has taken an active role in the pursuance of the RMA, as can be seen in the Strategic Defence Review (SDR) of 1998. The major technological focus in Great Britain revolves around the growth of a long-range precision force using Tornadoes, Harriers, and the future Eurofighter to provide air launch capabilities, and the Storm Shadow cruise missile, as a land-based system.[64] Emphasis has also been placed on the increase of battlespace awareness and towards such a goal the Royal Air Force (RAF) has developed the Airborne Stand-off Radar to provide 250-kilometer intelligence imagery and the Watchkeeper, surveillance UAV with an operational date of 2008.[65]

Similar to the U.S., the SDR has shifted doctrines from that focused upon the Cold War strategic environment to an expeditionary force based in power projection. The center of these plans is the creation of the Joint Rapid Reaction Force, consisting of

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[61] Galdi (1995), p. 22
[62] Sloan (2002), p. 43
[63] Ibid., p. 44
[64] Ibid., p. 56
[65] Ibid., p. 57

two echelons with 4 land brigades, 20 major warships, 22 other vessels, 110 combat aircraft and 160 support aircraft.[66] The RAF and Royal Navy have chosen to add increased airlift capabilities to their core competencies through aircraft procurement and container vessels to transport heavy equipment. Defense policy in the United Kingdom also includes a transformation from manned to unmanned vehicles and from open-sea maritime warfare to littoral warfare and force projection.[67]

France has also become an active participant in the RMA, reverting from the viewpoint that the RMA was a means for the U.S. to fully exploit their technological industry to an acceptance of the RMA as signaling a cultural transformation to the information age.[68] The most radical change presented in Present Chirac's Model 2015, the doctrinal paper for the French military, was the cancellation of France's traditional conscription system to be replaced by a fully professional, all-volunteer military.[69] Comparative with the U.S. and the U.K. doctrines, Model 2015 accepts the importance of intelligence, force projection, and the need for expeditionary forces. Toward this end, the French army is being re-organized into ten 'manoeuvre' brigades and six specialist brigades, formed from the new modular units which will make up the general structure and the French Air Force is focusing procurement efforts on airlift capabilities.[70] Unique to the new French organization is the development of four joint force headquarters dedicated to rapid reaction who do not have assigned units, but rather request units, when needed, to facilitate the specific task.[71]

German attention to the RMA mimics that of other nations, but remains unique due to the strategic history of the country during the Cold War. After four decades with a hostile border and military planning based around Soviet deep-Strike protection, Germany lacks both long-range and reactionary forces.[72] It wasn't until 2000, with the Commission on the Common Security and the Future of the Bundeswehr, that

[66] Ibid., p. 60
[67] Ibid., p. 60
[68] Géré (2000), p. 130
[69] Drion (1996), p. 99
[70] Sloan (2002), p. 68
[71] Ibid., p. 69
[72] Ibid., p. 74

Germany began instituting changes to doctrine and organization to reflect the RMA.[73] Unlike France, Germany will be reducing, rather than eliminating, the size of the conscript force, though conscripts are for home defense only and cannot be used for NATO or UN tasks.[74] Therefore, the German Army has created the 60,000 strong Krisenreaktionskräfte, a crisis reaction force dedicated to such actions.[75] Concomitant with these organisational changes, Germany has also placed an emphasis on procuring airlift capabilities and advanced intelligence, reconnaissance and surveillance facilities.[76]

Though conceptually still controlled by the U.S., the proposed RMA has been accepted and incorporated into the doctrines, organizations and procurement of other countries. The new technologies, in the areas of stealth technology, precision munitions, advanced sensors, and C^4I capabilities, and the related doctrinal and organizational innovations, provide concrete evidence identifying the existence of a worldwide RMA. However, no decisive conclusion about the revolutionary quality of the contemporary RMA can be currently made. Without the ability to analyze the future of warfare, the debate lacks the ability to prove that these innovations will result in a major change to the nature of warfare. Definitive conclusions on the existence and extent of the 'Information Revolution' must wait.

[73] Ibid., p. 72
[74] Neßhöver (2001), p. 1
[75] Ibid., p. 3
[76] Ibid., p. 4

Chapter 3: Space-Based Systems and the RMA

Though unable to provide definitive answers to the question of future war, the 'Information Revolution' suffers from another, more fundamental, problem. There exists a gap between the nature of this RMA and the technical innovations meant to provide these characteristics to the new form of warfare. This mismatch revolves around the need for a constant, global network of navigation, communication, ISR and data transfer systems to allow for the 'digitization' of the military. There lacks coherent discussions upon how these characteristics will be achieved, as they are not readily available given current capabilities. These characteristics can only be provided by the recognition and integration of space-based systems into the 'Information Revolution' strategy.

In discussing the importance of space-based systems, it is first necessary to bring to light the nature of the space environment, which endows these systems with the necessary characteristics unachievable in the terrestrial theater. 'The space environment offers the possibility of conducting worldwide military operations in a greatly reduced timeframe'.[77] The position of space in relation to the Earth creates the ideal 'high ground', providing a 'birds-eye' view of the situation. This elevated position allows for wide area monitoring for ISR and weather predicting systems, but also provides global line-of-sight links for direct or relay communications, data transfer and navigation.[78] This position relative to Earth also exempts satellites from restrictions, such as no-fly zones or hazardous terrain, which limits aerial vehicles. Furthermore, the nature of space gives the systems a predictable orbit and the ability to function autonomously, being both unmanned and requiring limited ground command input.[79] This allows for continuous operations over multiple years. Rather than being launched when needed within a certain area for an operation, satellites are able to monitor and provide support at all times. Finally, depending on the sensors used, satellites can have both nighttime and all weather capabilities.[80] These

[77] McKitrick et al. (1998), p. 2
[78] Cohen (1999), p. 67
[79] Mantz (1994), p. 1
[80] FAS (1992), p. 2

characteristics give space-based systems the ability to attain the global network capability, required to achieve the 'Information Revolution'.

The importance of space-based systems becomes apparent when examining the role of these systems during the Gulf War, and their interplay with such functions as navigation, communications, and intelligence, surveillance and reconnaissance. Along with providing a coherent look at the benefit of space-based systems, the operational limitation suffered by the military during this conflict illuminates areas of weakness which must be resolved before full exploitation of the new RMA is possible. By examining the systems used, including the ground control and user segment, the application of these systems to military operations, and the limitation to operational efficiency, it is possible to outline the niche of space-systems in the 'Information Revolution'.

Intelligence, Surveillance and Reconnaissance:

Perhaps the most well known contributions of space systems to the Gulf War were those connected with intelligence from satellite imagery. Early space systems were used mainly for early warning and arms control in the NATO Air/Land Doctrine during the Cold War.[81] Current military thought has expanded the roles of such systems, relying heavily on their ability to provide intelligence and surveillance. During the Gulf War, Coalition forces used imagery provided by three KH-11 photographic satellites, and a Lacrosse radar imager. Together, these systems provided updated images every two hours, on average, with gaps of no more than five hours.[82] The KH-11 satellite provides 24 hour imaging capability, with a 10-cm image resolution, image swath of 1000 kilometers, and repeating passes every 90 minutes.[83] The Lacrosse satellite employs a radar imager, which allows for both nighttime and all weather, including cloud cover, imaging at a resolution of approximately 10 meter and a 1000-kilometer swath.[84] Images of the area where also

[81] Mantz (1995), p. 2
[82] FAS (1997), p. 3
[83] Ibid., p. 3
[84] Ibid., p.3

technologies to give U.S. forces greater military capabilities through advanced concepts, doctrine and organization', broadening the focus of the RMA.[36] While accepting the technological advances as essential to the current RMA, emphasis was placed upon the advancement of doctrine—increased 'jointness', littoral warfare, high mobility ground forces, and long-range precision munitions—and organizational changes toward small, tailorable units and the decentralization of C^4I.[37] This view has become the most widely accepted as the true RMA. By analyzing the changes to doctrine, operational concepts, and organization it is possible to see the ways in which each country and branch of the military interprets the RMA and its presumed effect on future warfare.

Focusing on the United States, where the majority of the debate has ensued, Joint Vision 2010 and Joint Vision 2020 have outlined the doctrinal changes put forth by Joint Chiefs of Staff as necessary for all US forces and have supplied guidelines for each services' future doctrine. The emphasis of these two documents is placed on joint operations, with highly mobile, precise ground forces. Joint Vision 2010 was the first official military doctrine which discussed the RMA, developing four new operational concepts—dominant maneuver, precision engagement, focused logistics and full-dimensional protection—the combination of which provides full spectrum dominance.[38] Full-spectrum dominance is the capability of military forces to dominate operations throughout the spectrum of operations, while acting either unilaterally or with multinational partners.[39] This new core competency relies upon information superiority as the enabling concept. This core competency and the related operations concepts are repeated in Joint Vision 2020, which re-emphasized the need for more agile, more precise and more rapidly deployable forces, yet placed a higher value on conceptual innovation to successfully utilize the technology.[40] It reversed the verdict of Joint Vision 2010 on the ability of future forces to act with 'transparency' of the battlespace, and acknowledge the ever-present existence of friction: 'the danger of warfare, the existence of uncertainty and chance, unpredictable

[36] Sloan (2002), p. 33
[37] Ibid., p. 34
[38] Ibid., p. 34
[39] JV 2020 (2000), p. 4
[40] Sloan (2002), p. 34

provided by the French *Satellite pour l'Observation de la Terre* (SPOT) and LandSat, during periods of non-coverage by military satellites.[85]

The control segment for the intelligence systems was provided by the Committee on Imagery Requirements and Exploitation (COMIREX) and the satellite control facility at Onizuka Air Station.[86] These stations provided direction to the satellites as to where to image and when and where to download the images. The Intelligence Communications Architecture and the Imagery Acquisition and Management Plan of the Defense Intelligence Agency (DIA) accomplished the dissemination of the intelligence to the actual user. These centers either processed the information directly from satellite relay or provided mobile units in the field to forward the information directly to the commanders. While each service has a Tactical Exploitation of National Capabilities (TENCAP) unit, responsible for the intelligence dissemination, the weak integration between the different services and the national DIA, coupled with the limited in-theater equipment, caused long dissemination times and limited depth of dissemination.[87] Further integration and augmentation of the TENCAP units has been highlighted as necessary for the effective use of these systems in information warfare.

The operational benefit garnered from space-based systems was shown at all stages of the Gulf War. As early as the 17 July 1990, the U.S. Central Intelligence Agency (CIA) was provided with satellite imagery 'of Iraq's ominous military buildup...with photographs of Iraqi armored divisions—some 30,000 soldiers—moving toward Kuwait'.[88] The situation was given 24 hour monitoring after 2 August 1990, with the Iraqi invasion, and provided the U.S. with the necessary intelligence to convince Saudi Arabia to allow for the stationing of Coalition troops within their borders.[89] By this continuous surveillance, the U.S. intelligence services were able to maintain updated positions of all Iraqi troops, the effect of the embargo placed on the country, and the actions of Iraqi troops within Kuwait, including the dismantling of oil

[85] Gonzales (1999) p. 23
[86] FAS (1997), p. 3
[87] Ibid., p. 4
[88] Ibid., p. 7
[89] Ibid., p. 8

refineries, the ignition of oil fires, and the dumping of crude oil into the Persian Gulf. As Coalition air strike began against Iraq, pilots were provided with satellite images of the air defenses and targets, allowing for the quick establishment of air superiority, uncontested throughout the conflict.[90] On the eve of the ground attack, all units were provided with similar satellite imagery, highlighting the layout of enemy troops and the position of defensive structures.[91]

Despite the definite advantage conveyed to Coalition forces through satellite intelligence, limitations in equipment and technology hampered the overall benefit. While some restrictions were unavoidable, such as cloud coverage and deception techniques practiced by Iraq, many were caused by the systems themselves. Inadequate communications and dissemination programs caused the largest hindrance. 'The Army, Navy, and Air Force...fielded nine different intelligence collection and analysis systems that could not communicate with each other'.[92] Furthermore, the inability for accurate bomb damage assessment from satellite and aerial images alone made it impossible to know the exact damage done to Iraqi forces. While these images were able to provide information as to whether the equipment had suffered damage, they could not provide conclusive evidence of destruction or in-operability.[93] Also, a deficiency in intelligence was shown by the difficulty in destroying mobile SCUD missile launchers. The speed with which these structures could be assemble, used, disassembled and moved made them virtually 'untargetable' through standard intelligence and required the use of special forces on the ground to coordinate the strikes.[94] Even with these insufficiencies, the role of space-based intelligence was indispensable to the Gulf War campaign.

In the decade since the Gulf War significant improvements in sensors and systems have developed to allow the more efficient application of satellite intelligence to military operations. Current sensor technology allows for higher resolution images, provided by synthetic aperture radar technique, and higher quality intelligence

[90] Ibid., p. 11
[91] Ibid., p. 11
[92] Ibid., p 13
[93] Ibid., p. 14
[94] Ibid., p. 17

through moving target indication, interferometric radar, and foliage penetration.[95] The most recent photographic satellite launched is the DigitalGlobe™ Quickbird satellite, which provides sub-meter resolution in single and multi-spectral images.[96] U.S. military satellites are estimated to have a capability of five-inch resolution on photographic satellites and less than three meters for SAR and radar satellites.[97] Further technological advances are being made by the European Space Agency, the European Aerospace Industry, and the European Union Satellite Centre, working to increase sensor sensitivity on the Helios II and SARLupe satellites to improve resolution.[98] This continued focus on research and development of satellite intelligence systems shows recognition of the increasing importance that these systems, and renders them more useful to military operations.

The role of satellite intelligence and surveillance to the 'Information Revolution' can be derived from the experience in the Gulf War and the current capabilities. During the Gulf War, satellite provided 24-hour surveillance from 17 July the end of the conflict, with images of the complete theater. Aerial systems such as the AWACS and JSTARS are subject to limitations caused by no-fly zone, allowing surveillance of only Kuwait and part of Iraq rather than total theater coverage, and equipment requirements, being unable to provide constant aircraft coverage for extended periods of time.[99] However, the length of dissemination and processing time of satellite images restricts the tactical benefit of the intelligence, as they are unable to provide field commanders with immediate notification of troop movement. Furthermore, while aircraft have to be deployed to the area, satellite can provide a global network capable of monitoring developing situations or surveillance of possible threats. These characteristics of satellite intelligence make it necessary for the accomplishment of the information superiority needed for the core competencies of dominant maneuver, focused logistics and full-dimensional protection of the RMA.

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[95] Cohen (1999), p. 74
[96] Tourin (2002), p. 1
[97] Winderem (2002), p. 2
[98] EAI (2002), p. 2
[99] Cohen (1999), p. 75

Communications:

The integral part played by satellites in intelligence and surveillance is mimicked by the importance of satellite communication and data relay for tactical and strategic connectivity. Coalition forces in the Gulf War relied upon communications provided by the Fleet Satellite Communications system (FLTSATCOM), two Defense Satellite Communications System (DSCS), three Syncom IV satellite leased from the Hughes Corporation, the UHF Tactical Satellite (TACSAT) and the civilian Inmarsat phones for real-time command and control.[100] The data relay was coordinated through the use of the Satellite Data System (SDS), a constellation of two satellites in orbits which optimize the real-time imagery download.[101] This system was aided by NASA's Tracking and Data Relay Satellite System, which provided near real-time relay for low-altitude systems. The British Skynet system was also used heavily during the Gulf War, with the heaviest use by the Royal Air Force and Royal Navy.[102]

This range of satellite support allowed for a high level of connectivity to exist within and between each of the services. There were 40 separate satellite terminals, each providing 60 voice and five data channels, as well as supporting the information link between more than 10,000 computers in theater.[103] Satellite communications were responsible for maintaining the connection between the Tactical Air Control Center, who forwarded air-tasking orders to the 1st Tactical fighter wing, forward deployed troops and Special Forces, who carried satellite terminals capable of operation within 5 minutes of deployment, and data centers in California, Georgia, Hawaii, Virginia and Okinawa.[104] The lack of existing infrastructure in the area made satellite communications vital, as well as providing a link back to command centers within the U.S. and other Coalition countries.

While immense, the operational success of satellite communications was not complete. The main problem was caused by lack of resources, exhausting the system

[100] FAS (1997), p. 30
[101] Ibid., p. 30
[102] Hayward (1996), p. 36
[103] FAS (1997), p. 31
[104] Ibid., p. 31

and limiting communications equipment to upper echelon commanders. To complicate the lack of resources, the ground equipment was too cumbersome to be effectively used below brigade level. Some of this problem was eliminated through the use of Inmarsat satellite telephones—portable terminals for direct communications and secure cellular telephones for in-theater communications.[105] Further complications arose from Iraqi interference and jamming of communication nodes, highlighting the need for better anti-jamming capabilities. The satellite communications, while restricted by these constraints, 'were tremendous in tying together the entire operation across the spectrum, [allowing] commanders to exchange information in a way they never could before'.[106]

The current satellite communications capabilities reflect measures taken to optimize the operational value of the systems. The most pressing limitation of restricted capacity was addressed in both hardware and software. In 1999, advanced DSCS satellites were made operational, which provide greater throughput to extend their capacity.[107] Furthermore, new techniques of digital compression are now used to reduce the size of each package transmitted, allowing for increased communications on existing systems.[108] Continued additions to the FLTSATCOM and DSCS programs are allowing upgrades to be made to existing networks.[109] A new military communications system is also being developed in the U.S. within the MILSTAR program, consisting of satellites in geo-stationary and low-Earth orbits capable of providing jam-resistant, extreme high frequency communications capable of transmitting voice, text, and image data.[110] Other technological advances are being made in the mobile terminals, to increase their operational effectiveness at lower-echelon commands.[111] With this continued growth, the satellite communications available to the military will continue to increase in tactical and strategic importance.

[105] Ibid., p. 33
[106] Ibid., p. 34
[107] Cohen (1999), p. 70
[108] Ibid., p. 70
[109] FAS (1992), p. 6
[110] Gonzales (1999), p. 19
[111] FAS (1992), p. 9

The importance of satellite communication during the Gulf War illuminates the possibilities of this technology for the 'Information Revolution'. The most observable benefit of these systems is the supporting role played in information superiority. While the actual intelligence data can be supplied by space-borne, aerial or ground-based sensors, that information is useless until it is processed and disseminated to the correct units for operational use. While this may be possible with terrestrial systems in highly developed areas, satellite communications remain the best option for remote area or when time of transmission is critical. The global network possible with satellites would allow for immediate connectivity not only in the theater of operations but with intelligence or command centers anywhere in the world. This network is important with the use of expeditionary forces, allowing rapid deployment without the need for previously developed infrastructure. The connectivity also makes satellites necessary for the achievement of dominant maneuver and joint operations. The nature of dominant maneuver, and the reliance on dispersed location with mass effects, relies heavily on the ability to retain communications between units to coordinate actions. Similarly, joint operations require constant connectivity between the different services. To achieve the full capabilities of the 'Information Revolution', connectivity between forces must be constant and all encompassing, viable only through the use of satellite communication and data transfer.

Navigation:

The third area in which satellites play a fundamental role in the concept of the 'Information Revolution' is navigation. This was the most developed space system used during the Gulf War. The two navigation systems available for use in 1990 were the U.S. Navy's Transit satellite, used mainly on submarines, and Navstar's Global Positioning System (GPS). Sixteen GPS satellites were visible from the Gulf region, providing at least 20 hours of two-dimensional coverage, and 15 hours of coverage by three satellites providing altitude information as well.[112] This system provides an accuracy of 10 to 15 meter accuracy in all dimensions.[113]

[112] FAS (1997), p. 22
[113] Farrell (1998), p. 3

The operational application of these systems varies only slightly for the different services. Some U.S. Air Force F-16s, KC-135s and B-52s, and the three British Tornado GR.1 squadrons were equipped with GPS receivers to aid with joint operations and targeting.[114] In January of 1991, the French Puma helicopter was also provided with receivers to enhance the search-and-rescue capabilities. GPS receivers on attack aircraft were integrated with the Continuously Computed Impact Point systems to reduce errors in visual delivery, and were used by B-52 bombers to time-release bombs from high altitudes to reduce targeting error.[115] Satellite navigation is also necessary for the operation of the Predator UAV. Naval reliance on GPS is heavy due to the lack of navigation aids at sea, but applications of the system also include mine sweeping, rendezvous and aircraft operations.[116] The Army faced a similar lack of navigation aids in the Saudi desert, and therefore, required at least one vehicle with every unit be equipped with GPS navigation.[117] Satellite navigation was used by the Army to synchronize rendezvous points, increase the precision of attack, and, when combined with night vision goggles, increase the efficiency of nighttime operations.[118]

Though a widely used system, both in civilian and military applications, GPS does suffer from operational limitations. The system is very sensitive to interference or jamming, easily done by providing a false signal. Intriguingly, it is also possible to improve the accuracy of GPS navigation through a technique called differential GPS, where a ground-based signal, at a known location, is used to remove attenuation errors giving position accuracy within a few centimeters.[119] Also, the motion of the receiving antenna and multi-path reflections off ground objects can reduce position accuracy.

The benefit provide by satellite navigation to the 'Information Revolution' revolves mainly around precision engagement and dominant maneuver. With respect to precision engagement, the ability to know precise location of both friendly and enemy

[114] FAS (1997), p. 23
[115] Ibid., p. 24
[116] Ibid., p. 25
[117] Ibid., p. 24
[118] Ibid., p.24
[119] Farrell (1998), p. 178

forces is central for the concept by supplying the target's position. This capability can also facilitate precision in joint operations, reducing the risks of mapping errors, as all forces have the same reference. In addition, the guidance of long-range PGMs relies upon satellite navigation for targeting. The U.S. Navy's Stand-off Land Attack Missile and the Patriot cruise missiles are guided by GPS navigation.[120] Concerning the contribution to dominant maneuver, satellite navigation allows all units to know the relative positions of all other units, both friend and foe, throughout the battlespace in order to coordinate attack. Satellite navigational support for precision engagement and dominant maneuver are necessary for the full realization of the 'Information Revolution'.

The important contribution of space-based systems to the Gulf War is clearly. To relate these contributions to the discussion on the value of these systems to the 'Information Revolution' and future warfare, it is necessary to evaluate the role they will play at each level of full-spectrum dominance. Concerning operations in peacetime, the role of satellites will be mainly limited to information gathering and transfer. The main benefit for this level of conflict will be the faster diffusion and higher quality information to reduce misconception and allow for a more tailored response.[121] Satellites also add support to peacetime operations through weather information, navigation and communications for normal military operational capability.[122] In low-level conflict, such as peacekeeping, humanitarian assistance and military operations other than war, the value of satellites remain much the same as in that of peacetime. Satellites will provide the ability for continuous operations during times of crisis management when visible signs of military activity will work to inflame the situation.[123] Similarly, satellites can provide early notification of hostile activity and a stable network of communications, intelligence and navigation for rapid reaction forces.[124] During periods of overt military operations, satellites act as force multipliers through enhanced effectiveness, and provide a tactical edge to theater forces.[125] The operational value of satellites at these levels of conflict was displayed

[120] FAS (1992), p. 4
[121] O'Hanlon (2000), p. 130
[122] Stares (1987), p. 51
[123] AFDD 4 (1996), p. 11
[124] Ibid., p. 11
[125] Stares (1987), p. 72

during the Gulf War. However, at the current state of technological ability, higher levels of conflict will tactically require support from additional systems for effective operations.[126] Finally, satellites will help to return to peacetime normalcy be providing temporary replacements for destroyed communications and navigations facilities.[127] Satellites do and will continue to perform a vital role in full-spectrum dominance that has been identified as a core competency of the 'Information Revolution'.

Further evidence of the importance of space-based systems to the 'Information Revolution' can be seen through the analysis of the doctrinal and organizational changes that have occurred to accommodate the new needs of the military. The U.S. Joint Chief of Staffs issued Joint Publication (JP) 3-14 in 2001, which outlined the official doctrine to guide the development of each service's space programs. In this new doctrine, the concept of space combat was outlined, containing the operational concepts of space control, force enhancement, space support and force application. Space control is defined as the ability to gain and maintain space superiority, protecting allied ability to exploit space technologies while preventing the enemy from a similar capability.[128] This concept was further outlined in the Air Force Doctrine Document (AFDD) 4, where the space control would be provided by deception, disruption, denial, degradation and destruction of enemy space capabilities on a temporary or permanent basis.[129] The capability of space support is furnished by those systems able to deploy, augment, sustain, and replenish space forces through the use of spacelift, activation, space surveillance and telemetry, tracking and control (TT&C) competencies.[130] As these activities are currently controlled within the U.S. Air Force Space Command, AFDD 4 also considers these to be important. The concept of force enhancement, mentioned in JP 3-14 and Air Force doctrine, is the central idea in both the Naval and Army space doctrines. Defined as combat support in areas of navigation, communications, ISR, ballistic missile warning and environmental sensing, these functions are the visible impact of space on war fighting.

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[126] Ibid., p. 53
[127] AFDD 4 (1996), p. 13
[128] JP 3-14 (2001), p. 7
[129] AFDD 4 (1996), p. 5
[130] JP 3-14 (2001), p. 7

The Army Field Manual 100-18 recognizes the necessity of space in conducting full-dimensional operations, relying on space systems to provide the synchronization, command and control, intelligence and parallel planning necessary for successful operations.[131] Both the Army and Navy doctrines emphasize the need to include this ability down to the lower echelons of command. The final operational concept is that of force application which is the combat use of space systems.[132] This capability is currently limited by international treaties on the uses of space, resulting in the only operational asset being the use of navigation for precision-guided munitions and the attainment of battlespace dominance.[133] As is necessary for an RMA, these doctrinal changes are incorporating space into military operations to transform the war fighting capabilities to match that necessary for the 'Information Revolution'.

Organizationally, the movement within the U.S. is directed at coordinating all national space assets to optimize their effective use of these technologies. The need for a U.S. commander in space (USCINCSPACE) was identified in JP 3-14, to establish coherence and organization of training, equipping, maintaining and advancing U.S. space capability.[134] This commander would work with representatives from each of the service's space commands and form a semi-autonomous command. This idea was furthered when the Commission to Assess United States National Security Space Management and Organization published their Pursuant of Public Law outlining recommendations for the necessary organizational changes in government and military to exploit space. The Commission stated that with no direct oversight of national space capacity, the government failed to reflect the growing importance of space, which was 'essential to US national security...to manage crises and conflicts, to conduct military operation and develop military capabilities to assure attainment of US objectives'.[135] The recommendations of the Commission were to institute a Presidential Advisory Group and the Senior Interagency Group for Space, to provide civilian guidance directly to the president and to the National Security Council on space-related policy.[136] Similarly, a closer relationship was called for between the

[131] FM 100-8 (1995), p. 6
[132] AFFD 4 (1996), p. 7
[133] Ibid., p. 7
[134] JP 3-14 (2001), p. 3
[135] Rumsfeld (2001), p. 11
[136] Ibid., p. 89

Secretary of Defense, the Director of the CIA and DIA, and the military space commanders, formulated around the creation of a four star commander in chief for space, as was integral in JP 3-14.[137] Currently, the only structural change that has been enacted is the establishment of a US SPACECOM commander as a four star general, to oversee the Army, Navy and Air Force Space Commands and the North American Aerospace Defense Command.[138] While limited transformation of government and force structure has actually occurred, the identification of the need for organizational change highlights the role of space in the 'Information Revolution'.

[137] Ibid., p. 88
[138] AFDD 4 (1996), p. 34

Chapter 4: Conclusion

The capabilities provided by space-based systems to intelligence, surveillance, reconnaissance, navigation, communications and data transfer are essential to achieving the 'Information Revolution'. Based on the quasi-official definition of a revolution in military affairs, the 'Information Revolution' is the combination of stealth, precision force, advanced sensors and increased C^4I technology, as demonstrated during the Gulf War in 1991. From the plethora of analysis that has ensued, doctrinal and organizational changes have begun to mutate military structure around the world. From U.S. joint and service doctrines, the operational concepts of dominant maneuver, precision engagement, focused logistics and full-dimensional protection have become the foundation of military training and acquisition. As a result of these new concepts, full-spectrum dominance has emerged as the new core competency. In pursuit of this competency, military forces have begun re-structuring their forces into smaller, more mobile units which are readily deployable and can be tailored to the specific threat. These changes are seen not only in the U.S., but are being instigated in many NATO countries simultaneously. Though limited actual force transformation has transpired in the passed decade, concrete plans exist and forces are actively seeking to adapt to this new form of warfare. These technological advances accompanied by doctrinal and organizational innovations point to the emergence of the 'Information Revolution' as the current RMA. Definitive proof of the 'Information Revolution' must wait upon the verdict of history.

Yet the concept of the 'Information Revolution' suffers from a mismatch between actual and desired capabilities, revolving around the integration of space-based technologies. As was shown in the Gulf War, space-based systems have become a mainstay for current military operations in the areas of communications, navigation and intelligence, surveillance and reconnaissance. Despite the apparent benefit provided by these systems, the Gulf War displayed a major weakness in the exploitation of these capabilities. The lack of integration of these systems into military doctrine and essential equipment at all levels of command limited their operational effectiveness. The advantages provided to the military by space capabilities were severely limited because of these inadequacies, identifying the need

for coherency in technical capacity and operational art. This same weakness is present in the 'Information Revolution' due to a similar lack of attention given to space capabilities.

The nature of the space environment provides space-based systems with characteristics which are essential in the attainment of the 'Information Revolution'. The elevated position of these systems, in relation to terrestrial theaters, allows for wide area monitoring, and global line-of-sight relay. Furthermore, due to the orbital characteristics and the advanced control onboard, space systems require a minimum of ground control input and operate relatively autonomously. These characteristics give space-based systems the ability to establish a constant, global network, essential for the 'Information Revolution'.

Intelligence, surveillance and reconnaissance capabilities provided by space-systems are relied most heavily upon by the military. During the Gulf War, such systems provided long-term surveillance of the entire theater of operations beginning in July of 1990 and continuing until the resolution of the conflict. The intelligence gathered from space sensors was used in the coordination of both air and land actions, giving precise information on the position and nature of Iraqi forces. While these systems are limited by technical inadequacies, the shortcomings are being addressed through the advancement of sensors and improved resolution, to improve the quality of the intelligence. Despite the technical limitations, the operational ability of these systems were severely diminished by a long dissemination time, caused by a lack of in-theater equipment and inadequate organization, making it virtually useless at a tactical level. These problems, through continued enhancement of technical ability, integration of space-based system capabilities, and organizational adaptation, must be addressed to achieve information superiority, necessary for the 'Information Revolution'.

A similar lack of resources and effective integration of space-based systems found in the area of intelligence can be seen when analyzing the role of communications. Though imperative to the successful conduct of the Gulf War due to the lack of established infrastructure in the area, satellite communications was limited to upper

echelon commanders. The global network of communications is not useful to military operations unless it can be successfully employed at all levels. The improvement of these systems is necessary to help with the achievement of information superiority, by facilitating the quick diffusion of intelligence to the correct areas and by increasing in-theater connectivity. This connectivity is essential for the accomplishment of dominant maneuver and joint operations, cornerstones of the 'Information Revolution' hypothesis.

The final area of space-based systems used widely in the Gulf War was in the area of navigation. This capability, provided by the Navstar Global Positioning System, is a highly advance, and can be a highly accurate navigational tool. Unlike the other space-based systems, satellite navigation is highly integrated into military doctrine and organization, though there remains a limitation of equipment available to low-level combat troops. Furthermore, the reliance on satellite navigation for the guidance of long-range precision weapons has helped to elevate these capabilities in tactical importance. While this assimilation is helpful for successful exploitation of navigation capabilities, such focus must by retained to allow for wider dissemination of navigation resources to all levels of the military, and a recognition of the important role of satellite navigation to the accomplishment of dominant maneuver, joint operations, and precision engagement.

Analysis of space-based systems used in the Gulf War clearly shows the importance played in the areas of communications, navigation and intelligence, surveillance and reconnaissance. Yet, the lack of resources and doctrinal and organizational integration of these systems limited the effectiveness of the systems. This inadequacy must be addressed in the 'Information Revolution' hypothesis. In the decade following this conflict, increased procurement and continued advancement of technical capabilities have made space systems more effective for military operations. The advances in space systems have also generated doctrinal and organizational changes. The emergence of the operational concepts of space control, force enhancement, space support and force application help to integrate space capabilities into all levels of the conflict spectrum. These doctrinal changes are necessary and

must continue to complete the assimilation of space-based capabilities into military operations.

The amalgamation of space systems has and will require organizational changes for better control and management of national resources and to ensure an overall capability for all services. Coherent control and management of national space capabilities is necessary at all levels of political, strategic and military structures. This coherency will need to be achieved by highlighting space as a necessary national capability. The establishment of a unified military command in control of space capabilities and civilian committees at all levels of planning and budgeting, as suggested in the report by the Commission to Assess United States National Security Space Management and Organization, is imperative for the effective use of space in the 'Information Revolution'. At present, attention to the re-organization has been limited to the establishment of the USCINCSAPACE, for coherent military integration.

Civilian and military analysts around the world have produced a plethora of theories hypothesizing the outcome of the 'Information Revolution'. In the decade that has followed the Gulf War, the race for a competitive edge has led to technological, doctrinal and organizational change in militaries around the world. However, the 'Information Revolution' is fundamentally limited by the lack of emphasis placed on space-based capabilities. The promise of change and innovation contained in the 'Information Revolution' is achievable only through the full exploitation of space-based systems.

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